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Dr. Hubert Borgmann, MESSE BREMEN GMBH, Buergerweide, Bremen, actuator@messe-bremen.de

ELECTROACTIVE POLYMERS AS ARTIFICIAL MUSCLES CHANGING ROBOTICS PARADIGMS

Yoseph Bar-Cohen and Sean Leary
JPL/Caltech, (MC 82-105), 4800 Oak Grove Drive, Pasadena, CA 91109-8099
Phone 818-354-2610, Fax 818-393-4057, yosi@jpl.nasa.gov, web: http://ndea.jpl.nasa.gov

ABSTRACT

For many years, electroactive polymers (EAP) received relatively little attention due to the small number of available materials and their limited actuation capability. The recent emergence of EAP materials with large displacement response enabled great potentials for these materials. The main attractive characteristic of EAP is their operational similarity to biological muscles, particularly their resilience and ability to induce large actuation strains. Unique robotic components and miniature devices are being explored, where EAP serve as actuators. EAP are becoming increasingly attractive for space applications where there is a great need to reduce the mass, size, consumed power, and cost of the instrumentation used in NASA's future missions.

At JPL, a study is underway to develop effective EAP materials and employ them as actuators in space related robotic mechanisms. Two families of electroactive polymer (EAP) materials are investigated, including bending ion-exchange membrane metal composites (IPMC) and longitudinal electrostatically driven elastomers. These EAP induce a significant displacement and, using these materials, several mechanisms were developed including a gripper, manipulator arm and surface wiper. The manipulator arm was made of a composite rod with a lifting actuator consisting of a scrolled rope that is activated longitudinally by an electrostatic field. A gripper was made to serve as an end-effector consisting of multiple bending EAP fingers for grabbing and holding such objects as rocks. An EAP surface wiper was developed to remove dust from optical and IR windows as well as solar cells. These EAP driven devices are taking advantage of the large actuation displacement while accounting for the limitations in induced force.

The capabilities of EAP materials are changing the paradigm of robotics in terms of components and performance. In recognition of the need for international cooperation among the developers, users and potential sponsors, an SPIE Conference was organized for the first time on March 1-2, 1999, in Newport Beach, California. The conference was the largest ever on EAP, and it marked an important milestone, turning the spotlight onto these emerging materials and their potential. Following this success, an MRS conference was initiated to address the fundamental issues related to the material science of EAP. The WW-EAP newsletter was initiated to bring the worldwide EAP community even closer. A homepage was also created to link worldwide EAP research and development facilities websites. In recognition of the limitation of current EAP materials, the author challenged the R&D community to develop a robot equipped with EAP actuators that would win an arm wrestling match with a human opponent. In this paper, the current capabilities and potentials as well as the challenges of state-of-the art EAP will be reviewed.